

Life History and Feeding Behavior of *Nephaspis amnicola* Wingo^{1,2}

HARVEY A. YOSHIDA and RONALD F.L. MAU³

ABSTRACT

The life history and feeding behavior of the coccinellid *Nephaspis amnicola* Wingo, were studied in the laboratory. Eggs hatched in an average of 6.9 days. The 1st, 2nd, 3rd, and 4th larval stages were completed in an average of 3.1, 2.3, 2.6, and 5.3 days, respectively. The pupal stage was completed in an average of 6.2 days. Adult longevity varied greatly; males and females lived for an average of 349 and 162 days, respectively. Each female laid an average of 212 eggs, and the ovipositional period was 131 days.

Prey-finding by larvae and adults depended upon chance contact. Feeding was by extraction and regurgitation.

In 1978, the spiraling whitefly, *Aleurodicus dispersus* Russell, was discovered in Hawaii and soon became a serious pest of landscape ornamentals as well as papaya, banana, mango, and guava. Because of its wide host range and the widespread distribution of hosts, biological agents were sought to control this introduced pest. In 1979–80 Hawaii Department of Agriculture (HDOA) entomologists released 3 species of predaceous coccinellids and 2 species of parasitic wasps.

The coccinellid, *Nephaspis amnicola* Wingo, was the first beneficial species introduced. Specimens were collected by HDOA exploratory entomologist R. Burkhart from Honduras and Trinidad in 1979. After preliminary host range studies under quarantine, *N. amnicola* was released on Oahu in October 1979 and became established soon after (Kumashiro et al. 1983).

N. amnicola was described by Wingo (1952) from a specimen collected in Boone, Iowa in 1949. Gordon (1972) reported that all members of the genus *Nephaspis* are restricted to the Western Hemisphere and that *N. amnicola* was extremely widespread, occurring in Barbados, Dominica, Curacao, Trinidad, Honduras, Panama, Costa Rica, and Florida.

We report here the results of laboratory studies on the biology of this spiraling whitefly predator.

MATERIALS AND METHODS

Rearing

Life history studies were conducted from June 1980 to November 1981 (Yoshida 1982). *N. amnicola* was reared at 23–26°C, 52–78% RH. Stock cultures of adults were confined in 7 dr. polystyrene vials, and fed spiraling whitefly nymphs on leaf sections of sea grape, *Coccoloba uvifera* (L.) Jacq. Moisture condensation within the rearing vials was alleviated by nylon organdy covered holes in the bottoms of the vials. Vial mouths were plugged with cotton.

The eggs of *N. amnicola* (n=85) were placed singly on a leaf section containing spiraling whitefly nymphs, and leaf sections were placed on wet cotton in covered 60 × 15 mm polystyrene petri dishes. Ventilation holes in petri dish lids were covered with nylon organdy. Water was added to the cotton daily to maintain leaf turgidity.

¹Coleoptera: Coccinellidae.

²Journal Series No. 2769 of the Hawaii Institute of Tropical Agriculture and Human Resources.

³Department of Entomology, University of Hawaii, Honolulu, Hawaii 96822.

TABLE 1. Duration of the immature stages of *Nephaspis amnicola* Wing reared at 23–26°C, 51–78% RH.

Life Stage	No. Observed	Range (Days)	Mean \pm S.D. (Days)
Egg	78	6.0 – 8.0	6.9 \pm 0.6
Larva	43	11.0 – 16.0	13.1 \pm 1.2
First stage	65	2.0 – 5.0	3.1 \pm 0.6
Second stage	64	2.0 – 4.0	2.3 \pm 0.6
Third stage	48	2.0 – 4.0	2.6 \pm 0.5
Fourth stage	43	4.0 – 7.0	5.3 \pm 0.7
Pupa	43	6.0 – 8.0	6.2 \pm 0.4
Total (Egg-Adult)	43	24.0 – 29.0	26.0 \pm 1.0

Newly emerged adults were sexed according to pronotum color and paired, and individual pairs were placed with food into rearing vials. Leaf sections were removed and examined daily; oviposition and mortality data were recorded.

Feeding Behavior

Feeding and prey-encountering behavior were studied by placing starved (24 h) larvae and adults on leaf sections which contained few spiraling whitefly nymphs. Prey consumption capacity was determined by releasing larvae and adults on leaves with known numbers of fourth stage whitefly nymphs.

Host Range

N. amnicola adults were starved 24 h prior to placement with each of the following hosts: *Tetranychus cinnabarinus* (Boisduval), *Myzus persicae* (Sulzer), *Coccus viridis* (Green), *Trialeurodes vaporariorum* (Westwood), *Orchamoplatus mammaeferus* (Quaintance and Baker), and *Aleurothrixus floccosus* (Maskell).

RESULTS AND DISCUSSION

Development of *N. amnicola* (egg to adult) was completed in an average of 26 days (SD=1). The duration of each stage is given in Table 1.

Egg: The light green, oblong eggs were 0.38 ± 0.02 mm long and 0.21 ± 0.01 mm wide (n=100). They were inconspicuous and usually deposited flat on the leaf surface within the flocculent material deposited by *A. dispersus*. Interestingly, they were often placed adjacent to or on a 4th stage spiraling whitefly nymph.

The color remained the same throughout incubation and the only obvious change was when the larva's ocelli became visible through the chorion after the fifth day. The chorion's surface was sculptured with a net-like pattern which became more discernible after eclosion. When examined with a scanning electron microscope, the pattern consisted of a double row of round protrusions which were arranged in adjoining pentagonal and hexagonal shapes (Fig. 1). The larva escaped through a longitudinal fracture in the chorion at eclosion.

Larva: Although there were no gross morphological differences between the larval stages other than size, differences in chaetotaxy were observed (Fig. 2A). There were 30, 32, 34, and 36 pronotal setae, 24, 26, 28, and 28 mesonotal setae, and 24, 24, 26, and 22 metanotal setae on the 1st, 2nd, 3rd, and 4th stage larvae,

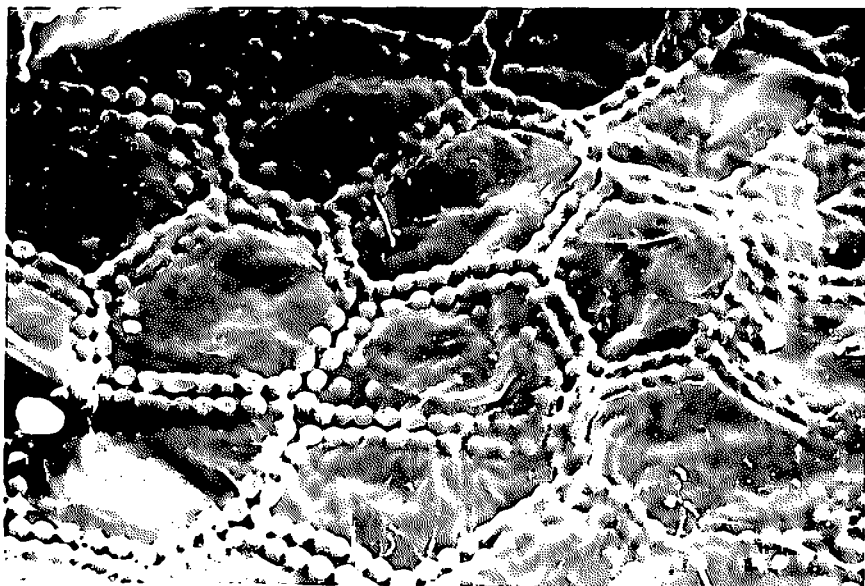


FIGURE 1. Scanning electron micrograph of *Nephaspis amnicola* Wingo egg chorion.

respectively. The first 8 abdominal segments possessed a pair of supraspiracular verrucae and the number and length of setae on the verrucae increased with successive stages. There were 1, 2–3, 4–5, and 9–10 setae on each supraspiracular verrucae of the 1st, 2nd, 3rd, and 4th stage larva, respectively.

White flocculent material secreted by the spiraling whitefly often accumulated on the setae of the larvae. This was more evident on older larvae probably due to the increased length and number of setae.

All stages of larvae were pale white. First stage larvae commenced searching for food almost immediately after hatching. Body measurements of each stage larvae were difficult to obtain because of the spiraling whitefly's flocculent material. First, 2nd, 3rd, and 4th stage larvae were 0.66 ± 0.08 ($n=66$), 1.35 ± 0.12 ($n=60$), 1.98 ± 0.22 ($n=59$), and 2.40 ± 0.26 ($n=58$) mm long, respectively.

Pupa: The newly formed pupae were pale white and attached to the leaf under-surface by the last abdominal segment of the 4th stage larval exuviae (Fig. 2B). Pupae averaged 1.48 ± 0.11 mm and 1.06 ± 0.04 mm in length and width, respectively ($n=68$). The dorsal surface bore scattered dark colored setae of varying lengths. The distal end of each seta had a tiny droplet of clear liquid upon maturation of the pupa.

Adult: Both sexes were about the same size measuring 1.44 ± 0.06 in length and 0.98 ± 0.04 mm in width ($n=61$) (Fig. 2C). Body color ranged from piceous to black. The body was convex and pubescent. Mouthparts were directed postero-ventrally, and the basal segment of the antennae was enlarged. Six abdominal sterna were visible. Males were easily distinguished from females by the pronotum color; yellow in males and black in females.

Teneral adults remained partially within the cast pupal case and were quiescent for ca. 48 hr. Adults emerged from the pupal case through a tear in the anterodorsal region. Sex ratio was 1:1 ($n=70$). Mating occurred 9–10 days after imaginal eclosion

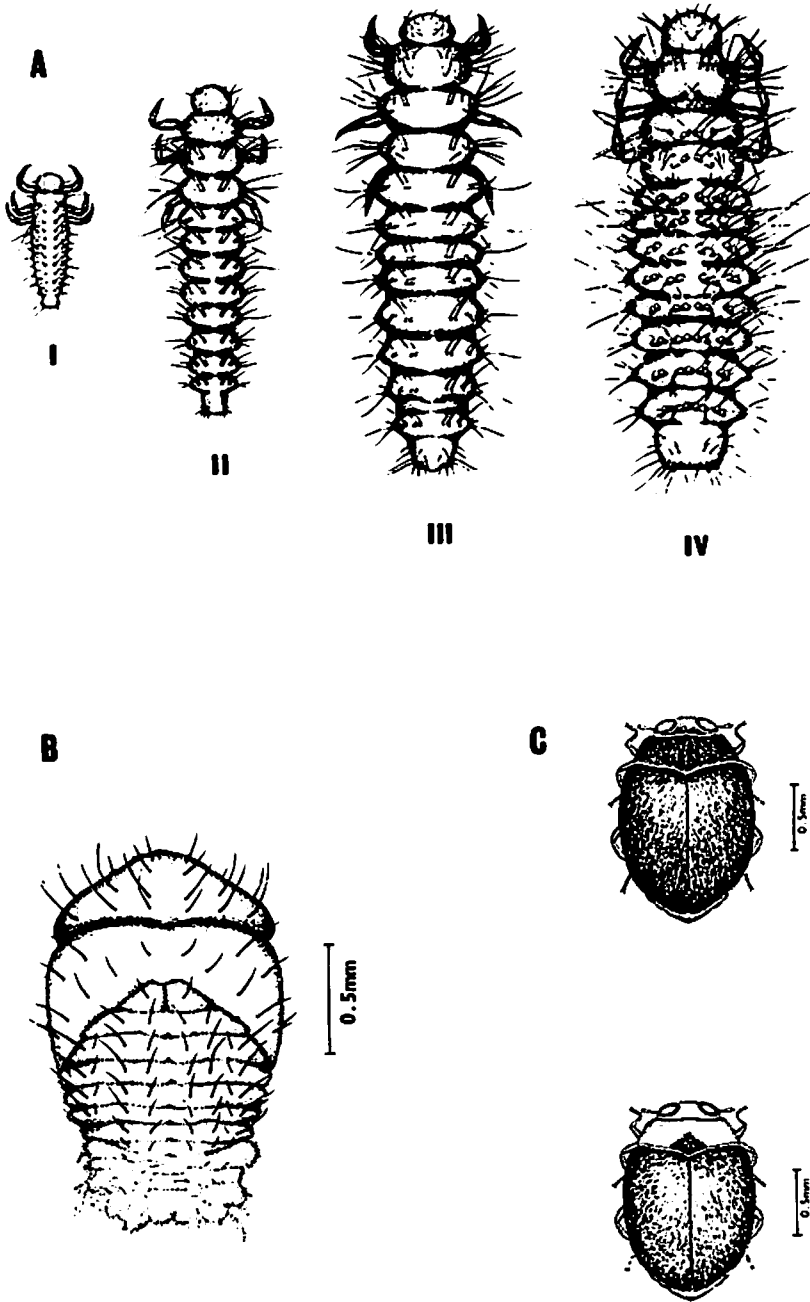


FIGURE 2. Larval stages (A, I-IV), pupa (B), and adult male and female (C) of the coccinellid *Nephaspis amnicola* Wingo.

with repeated matings occurring thereafter. The longest period in copulo was ca. 13 min. Oviposition occurred an average of 2.6 days ($n=17$) after first mating and most of the eggs were laid within 49 days; the ovipositional period was 131 ± 35 days ($n=11$). Each female laid an average of 212 ± 52 eggs and lived for 162 ± 58 days ($n=11$). Males lived for 349 ± 140 days ($n=22$).

Prey-encountering and Feeding

Prey encountering behavior of the larvae was random (Yoshida 1982). The larvae frequently altered their direction of movement which invariably resulted in a meandering pattern. The larvae stopped often, affixed their caudal segments to the leaf and moved their bodies from side to side. It appeared that they were not able to perceive the prey readily and chance encounters were essential for procurement of food. Similar observations were made in studies of *Stethorus picipes* (Fleschner 1950), *Propylea quatuordecempunctata* (Banks 1957), *Hippodamia quinquesignata* (Kaddou 1960), and *Stethorus siphonulus* (Raros and Haramoto 1974).

Larval behavior changed after locating and feeding on prey; movements intensified and were characterized by slow, deliberate movements. Larvae made frequent stops, attached their caudal segments to the leaf, and moved their bodies from side to side. Initially, larvae concentrated their movement in the area surrounding the immediate feeding site, but if no additional prey were found, the larvae began moving more rapidly and consequently increased the area covered.

Prey encountering by adults also was random. They rarely walked in one direction for an extended period. They frequently covered a particular area repeatedly and were unable to find prey populations nearby. Adults were comparatively more capable of encountering prey than larvae since they were able to cover a larger area more rapidly than larvae.

Adults and larvae pierced the integument of prey with their mandibles and withdrew body contents. The body contents and salivary secretions were then regurgitated back into the prey. Putman (1955) described similar feeding behavior in *S. punctillum* Weise. A series of extractions and regurgitations continued throughout the feeding episode. Only the exoskeleton or chorion of the prey remained when feeding was completed.

The majority of the prey consumed were nymphs although *N. amnicola* fed on all spiraling whitefly stages. The relative feeding capacity of different *N. amnicola* stages on 4th stage spiraling whitefly nymphs is given in Table II. Larvae consumed an average of 17.7 whitefly nymphs during development from egg to pupa. Adults consumed an average of 36.6 during the first 14 days after emergence.

Cannibalism among larvae and adults occurred at times. With ample prey, cannibalism was never observed, but when larvae were deprived of food and confined together, cannibalism occurred within 12 h. On several occasions, newly hatched larvae were observed feeding on *N. amnicola* eggs when no other food was available.

In addition to feeding on preferred hosts, predaceous coccinellids often consume numerous other species of insects (Hodek 1973). While *N. amnicola* may prefer feeding on spiraling whitefly, other insects occurring on the same hosts may be consumed. Adults actively fed on *T. vaporariorum*, *O. mammaeferus*, and *A. floccosus* in laboratory studies and were observed feeding on the latter 2 species in the field. They also fed on all stages of *T. cinnabarinus* to a limited extent. We do not know whether or not development and reproduction can occur on these species. No feeding occurred on *C. viridis* or *M. persicae*.

TABLE II. Number of fourth stage *Aleurodicus dispersus* Russell nymphs consumed by the larval and adult stages of *Nephaspis amnicola* Wingo.

Stage of Predator	No. Predators	No. Prey Consumed	
	Observed	Range	Mean \pm S.D.
Larva			
First stage	10	1.0 - 5.0	3.1 \pm 1.2
Second stage	10	1.0 - 4.0	2.2 \pm 1.0
Third stage	10	1.0 - 6.0	3.5 \pm 2.0
Fourth stage	10	6.0 - 13.0	8.9 \pm 2.3
Total (Larva)	10	13.0 - 23.0	17.7 \pm 3.6
Adult*	10	23.0 - 46.0	36.6 \pm 6.6
Number Consumed/Day	10	0.0 - 7.0	2.6 \pm 0.5

*Adults were observed for 14 days starting on the day of eclosion.

ACKNOWLEDGMENTS

We thank Dr. Frank Haramoto and entomologists of the Hawaii Department of Agriculture for their help.

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